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(54) Title: PROCESS FOR IMIDAZO[4,5-*c*]PYRIDIN-4-AMINES

(57) Abstract: A process and intermediates for preparing 1*H*-imidazo[4,5-*c*]pyridin-4-amines are disclosed. The process includes providing a 7*H*-imidazo[4,5-*c*]tetrazolo[1,5-*a*]pyridine and converting a 7*H*-imidazo[4,5-*c*]tetrazolo[1,5-*a*]pyridine to a 1H-imidazo[4,5-*c*]pyridin-4-amine.

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PROCESS FOR IMIDAZO[4,5-*c*]PYRIDIN-4-AMINES

FIELD

This invention relates to processes for preparing 1*H*-imidazo[4,5-*c*]pyridin-4-amines and to intermediates for use in preparing 1*H*-imidazo[4,5-*c*]pyridin-4-amines.

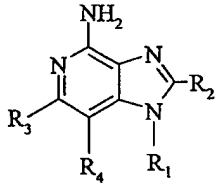
BACKGROUND

There has been a major effort in recent years to prepare and find compounds that modulate the immune system. Certain 1*H*-imidazo[4,5-*c*]pyridin-4-amine compounds useful as immune response modifiers and methods for their preparation are described, for example, in U. S. Patent Nos. 5,446,153; 5,494,916; 5,644,063; 6,525,064; 6,545,016; and 6,545,017, in International Publication No. WO 02/46194, and in U.S. Patent Publication No. 2004/0010007.

However, despite these developments, there is a continuing need for useful, alternative processes and intermediates for preparing immune response modifying 1*H*-imidazo[4,5-*c*]pyridin-4-amines.

SUMMARY

It has now been found that 1*H*-imidazo[4,5-*c*]pyridin-4-amine compounds of the Formula I



I

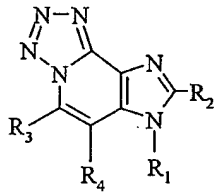
and pharmaceutically acceptable salts thereof, wherein R_1 is selected from hydrogen; CHR_xR_y wherein R_x is hydrogen and R_y is selected from alkyl or cyclic alkyl containing one to ten carbon atoms, alkenyl containing two to ten carbon atoms, hydroxyalkyl containing one to six carbon atoms, alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon atoms, benzyl, and

phenylethyl; and $-C=CR_zR_z$ wherein each R_z is independently alkyl or cyclic alkyl of one to six carbon atoms;

R_2 is selected from hydrogen; alkyl containing one to eight carbon atoms; hydroxyalkyl containing one to six carbon atoms; alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon atoms; benzyl; phenylethyl; phenyl; the benzyl, phenylethyl, or phenyl substituent being optionally substituted on the benzene ring by a moiety selected from methyl, methoxy, and halogen; and morpholinoalkyl wherein the alkyl moiety contains one to four carbon atoms; and

R_3 and R_4 are independently selected from hydrogen and alkyl of one to five carbon atoms, can be prepared by a process comprising the steps of:

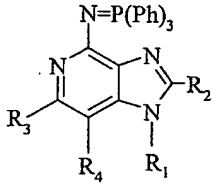
providing a compound of Formula VII



VII

wherein R_1, R_2, R_3, and R_4 are as defined above;

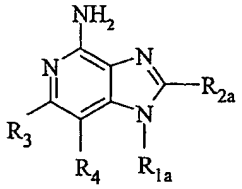
reacting the compound of Formula VII with triphenylphosphine to provide an *N*-triphenylphosphinyl compound of Formula VIII



VIII; and

hydrolyzing the *N*-triphenylphosphinyl compound of Formula VIII to provide a compound of Formula I.

In other embodiments, 1*H*-imidazo[4,5-*c*]pyridin-4-amine compounds of the Formula Ia



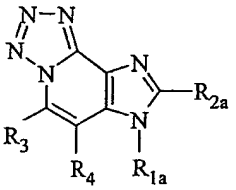
Ia

and pharmaceutically acceptable salts thereof, wherein R_{1a} is selected from hydrogen and CHR_xR_y wherein R_x is hydrogen and R_y is selected from alkyl or cyclic alkyl containing one to ten carbon atoms, hydroxyalkyl containing one to six carbon atoms, and alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon atoms;

R_{2a} is selected from hydrogen; alkyl containing one to eight carbon atoms; hydroxyalkyl containing one to six carbon atoms; alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon atoms; and morpholinoalkyl wherein the alkyl moiety contains one to four carbon atoms; and

R_3 and R_4 are independently selected from hydrogen and alkyl of one to five carbon atoms, can be prepared by a process comprising the steps of:

providing a compound of Formula VIIa



VIIa

wherein R_{1a}, R_{2a}, R_3, and R_4 are as defined above;

reductively removing the tetrazolo ring from the compound of Formula VIIa to provide a compound of the Formula Ia.

In some embodiments the above processes further comprise the step of isolating the compound of Formula I, the compound of Formula Ia, or pharmaceutically acceptable salts thereof.

In another aspect this invention provides intermediate compounds of the Formulas IV-VII, described below, which are useful in the preparation of the compounds of Formula I and Ia, for example, in the processes described herein.

As used herein, the terms "alkyl", "alkenyl", and the prefix "alk-" are inclusive of straight chain and branched chain groups.

The terms "comprising" and variations thereof do not have a limiting meaning where these terms appear in the description and claims.

The above summary of the present invention is not intended to describe each disclosed embodiment or every implementation of the present invention. The description that follows more particularly exemplifies illustrative embodiments. Guidance is also provided herein through lists of examples, which can be used in various combinations. In each instance, the recited list serves only as a representative group and should not be interpreted as an exclusive list.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS OF THE INVENTION

Reaction Scheme I illustrates one embodiment of the invention where R_1, R_2, R_3 and R_4 are as defined above.

In step (1) of Reaction Scheme I a 2,4-dichloro-3-nitropyridine of Formula II is reacted with an amine compound of formula R_1NH_2, wherein R_1 is as defined above, to provide a 2-chloro-3-nitropyridine of Formula III. In some embodiments the compound of formula R_1NH_2 is selected from 2-hydroxy-2-methylpropylamine, 2-methylpropylamine, and *n*-butylamine. The reaction may be carried out in an inert solvent such as *N,N*-dimethylformamide or dichloromethane in the presence or in the absence of a base such as triethylamine at a reduced temperature, or at an elevated temperature up to the reflux temperature of the solvent. For example, the reaction can be carried out by adding the amine to a solution of a compound of Formula II in a suitable solvent such as *N,N*-dimethylformamide in the presence of a tertiary amine such as triethylamine at a reduced temperature, e.g., about 0 °C. The product can be isolated from the reaction mixture using conventional methods. Many 2,4-dichloro-3-nitropyridines of the Formula II are known and can be readily prepared using known synthetic methods. (See, for example, Dellaria et al, U.S. Pat. No. 6,525,064 and the references cited therein.)

In step (2) of Reaction Scheme I a 2-chloro-3-nitropyridine of Formula III is reacted with an alkali metal azide to provide an 8-nitrotetrazolo[1,5-*a*]pyridin-7-amine of

Formula IV. The reaction can be carried out by combining the compound of Formula III with an alkali metal azide, for example, sodium azide, in a suitable solvent such as N,N-dimethylformamide and heating, for example to about 50-60 °C, optionally in the presence of ammonium chloride. Alternatively, the reaction can be carried out by combining the compound of Formula III with an alkali metal azide, for example, sodium azide, in a suitable solvent such as acetonitrile/water, preferably 90/10 acetonitrile/water, in the presence of cerium III chloride, preferably cerium III chloride heptahydrate. Optionally, the reaction can be carried out with heating, for example, at the reflux temperature. The product can be isolated from the reaction mixture using conventional methods.

In step (3) of Reaction Scheme I an 8-nitrotetrazolo[1,5-*a*]pyridin-7-amine of Formula IV is reduced to provide a tetrazolo[1,5-*a*]pyridine-7,8-diamine of Formula V. The reduction can be carried out using a conventional heterogeneous hydrogenation catalyst, for example, platinum on carbon or palladium on carbon. The reaction can conveniently be carried out on a Parr apparatus in a suitable solvent such as ethanol, isopropanol or toluene. Alternatively, Ni_2B can be generated in situ from sodium borohydride and $NiCl_2$ in the presence of methanol. The compound of Formula V is added to the reducing agent solution to effect reduction of the nitro group. When the compound of Formula V contains an alkenylene moiety, the Ni_2B reducing agent can be used without reducing the alkenylene moiety. The product can be isolated from the reaction mixture using conventional methods.

In step (4) of Reaction Scheme I a tetrazolo[1,5-*a*]pyridine-7,8-diamine of Formula V is reacted with a carboxylic acid of the formula R_2CO_2H; an equivalent thereof selected from the corresponding acyl halide, $R_2C(O\text{-alkyl})_3$, and $R_2C(O\text{-alkyl})_2(O(O{=})C\text{-alkyl})$; or a mixture thereof, wherein R_2 is as defined above and each alkyl contains 1 to 8 carbon atoms, to provide a 7*H*-imidazo[4,5-*c*]tetrazolo[1,5-*a*]pyridine of Formula VII. The reaction can be run in the absence of solvent or in an inert solvent such as, for example, toluene. The reaction may be run in the presence of cyclization conditions, which include sufficient heating (e.g., about 80-150 °C) to drive off any alcohol or water formed as a byproduct of the reaction, and optionally, in the presence of a catalyst such as pyridine hydrochloride. For example, an orthoester of the formula $R_2C(O\text{-alkyl})_3$, (e.g., triethylorthoacetate) is combined with a tetrazolo[1,5-*a*]pyridine-7,8-diamine of Formula V in toluene in the presence of pyridine hydrochloride and heated at the reflux

temperature. The product or a pharmaceutically acceptable salt thereof can be isolated from the reaction mixture using conventional methods.

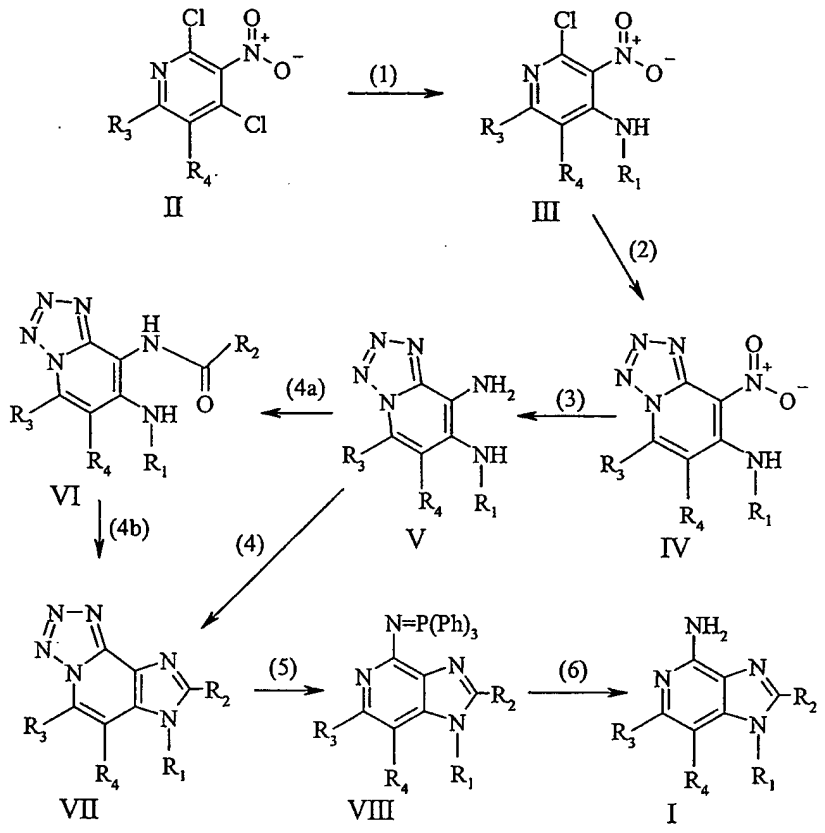
Alternatively, step 4 can include steps (4a) and (4b) of Reaction Scheme I. In step (4a) a tetrazolo[1,5-*a*]pyridine-7,8-diamine of Formula V is reacted with a carboxylic acid of the formula R_2CO_2H, the corresponding acyl halide, or a mixture thereof, wherein R_2 is as defined above, to provide an *N*-[tetrazolo[1,5-*a*]pyridin-8-yl]amide of Formula VI. The reaction can be run in an inert solvent such as toluene, dichloromethane, acetonitrile, or pyridine at a reduced temperature, such as about 0 °C. For example, an acyl halide can be added to a solution of the compound of Formula V in dichloromethane at about 0 °C in the presence of triethylamine. The product can be isolated from the reaction mixture using conventional methods.

In step (4b) of Reaction Scheme I an *N*-[tetrazolo[1,5-*a*]pyridin-8-yl]amide of Formula VI is cyclized to provide a 7*H*-imidazo[4,5-*c*]tetrazolo[1,5-*a*]pyridine of Formula VII. The reaction can be run at an elevated temperature, such as a reflux temperature, sufficient to drive off any water formed as a by-product of the reaction. Optionally, a catalyst such as pyridine hydrochloride can be included. The reaction can be run in the absence of a solvent or in an inert solvent, for example, a solvent have a boiling point of about 80 °C to about 150 °C, preferably at least about 100 °C, (e.g., toluene, pyridine). The product or a pharmaceutically acceptable salt thereof can be isolated from the reaction mixture using conventional methods.

In step (5) of Reaction Scheme I a 7*H*-imidazo[4,5-*c*]tetrazolo[1,5-*a*]pyridine of Formula VII is reacted with triphenylphosphine to form an *N*-triphenylphosphinyl intermediate of Formula VIII. The reaction with triphenylphosphine can be run in a suitable solvent such as toluene or 1,2-dichlorobenzene under an atmosphere of nitrogen with heating, for example at the reflux temperature.

In step (6) of Reaction Scheme I an *N*-triphenylphosphinyl intermediate of Formula VIII is hydrolyzed to provide a 1*H*-imidazo[4,5-*c*]pyridin-4-amine of Formula I. The hydrolysis can be carried out by general methods well known to those skilled in the art, for example, by heating in a lower alkanol in the presence of an acid. The product can be isolated from the reaction mixture using conventional methods as the compound of Formula I or as a pharmaceutically acceptable salt thereof.

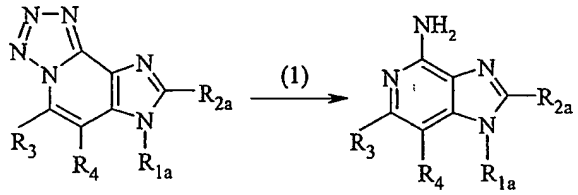
Reaction Scheme I



Reaction Scheme II also illustrates an embodiment of the invention where R_{1a}, R_{2a}, R_3 and R_4 are as defined above.

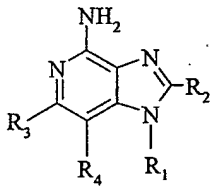
In step (1) of Reaction Scheme II, the tetrazolo ring is reductively removed from a 7*H*-imidazo[4,5-*c*]tetrazolo[1,5-*a*]pyridine of the Formula VIIa to provide a 1*H*-imidazo[4,5-*c*]pyridin-4-amine of the Formula Ia or a pharmaceutically acceptable salt thereof. The reaction can be carried out by reacting the 7*H*-imidazo[4,5-*c*]tetrazolo[1,5-*a*]pyridine of Formula VIIa with hydrogen in the presence of a catalyst and an acid. The reaction can be conveniently run in a Parr apparatus with a suitable catalyst, such as platinum IV oxide, and a suitable acid, such as trifluoroacetic acid or concentrated hydrochloric acid. The product can be isolated from the reaction mixture using conventional methods.

Reaction Scheme II



When an alkenyl, alkenylene, or other readily reducible moiety is present and is to be kept from being reduced during the removal of the tetrazolo ring, steps (5) and (6) of Reaction Scheme I are preferred over Reaction Scheme II. For example, benzyl, phenylethyl, and $-C=R_zR_z$ moieties may be reduced or partially reduced in Reaction Scheme II.

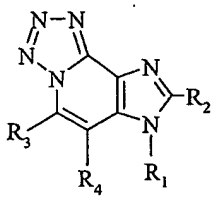
In one embodiment, the present invention provides a process (i) for preparing 1*H*-imidazo[4,5-*c*]pyridin-4-amine compounds of the Formula I



I

and pharmaceutically acceptable salts thereof wherein R_1, R_2, R_3, and R_4 are as defined above, which process comprises the steps of:

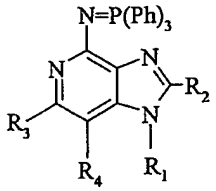
providing a compound of the Formula VII



VII

wherein R_1, R_2, R_3 and R_4 are as defined above;

reacting the compound of Formula VII with triphenylphosphine to provide an *N*-triphenylphosphinyl intermediate of Formula VIII



VIII

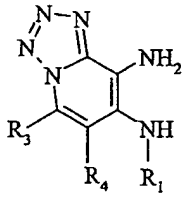
wherein R_1, R_2, R_3 and R_4 are as defined above; and

hydrolyzing the *N*-triphenylphosphinyl intermediate of Formula VIII to provide a compound of Formula I.

In another embodiment, the above process (i) further comprises the step of isolating the compound of Formula I or a pharmaceutically acceptable salt thereof.

In another embodiment, a process (ii) comprises the above process (i) further comprising the steps of:

providing a compound of Formula V



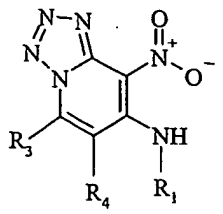
V

wherein R_1, R_3 and R_4 are as defined above; and

reacting a compound of the Formula V with a carboxylic acid of the formula R_2CO_2H; an equivalent thereof selected from the corresponding acyl halide, $R_2C(O\text{-alkyl})_3$, and $R_2C(O\text{-alkyl})_2(O(O{=})C\text{-alkyl})$; or a mixture thereof, wherein R_2 is as defined above, and each alkyl contains 1 to 8 carbon atoms, to provide a compound of the Formula VII.

In another embodiment, a process (iii) comprises the above process (ii) further comprising the steps of:

providing a compound of Formula IV



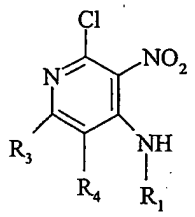
IV

wherein R_1, R_3 and R_4 are as defined above; and

reducing the compound of Formula IV to provide a compound of the Formula V.

In another embodiment, a process (iv) comprises the above process (iii) further comprising the steps of:

providing a compound of Formula III



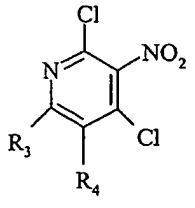
III

wherein R_1, R_3 and R_4 are as defined above; and

reacting the compound of Formula III with an alkali metal azide to provide a compound of the Formula IV. In certain embodiments, the compound of Formula III is reacted with the alkali metal azide in the presence of cerium III chloride.

In another embodiment, a process (v) comprises the above process (iv) further comprising the steps of:

providing a compound of Formula II



II

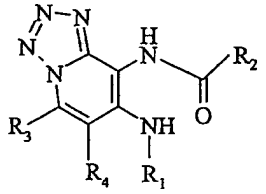
wherein R_3 and R_4 are as defined above; and

reacting the compound of Formula II with a compound of the formula R_1NH_2, wherein R_1 is as defined above, to provide a compound of the Formula III.

In another embodiment, the above process (v) further comprises the step of isolating the compound of Formula I or a pharmaceutically acceptable salt thereof.

In one embodiment, a process (vi) comprises the above process (i) further comprising the steps of:

providing a compound of Formula VI



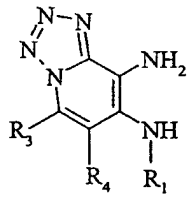
VI

wherein R_1, R_2, R_3 and R_4 are as defined above; and

subjecting the compound of Formula VI to cyclization conditions, to provide a compound of the Formula VII.

In another embodiment, a process (vii) comprises the above process (vi) further comprising the steps of:

providing a compound of Formula V



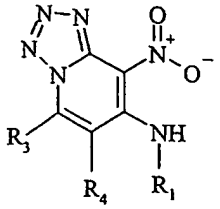
V

wherein R_1, R_3 and R_4 are as defined above; and

reacting a compound of the Formula V with a carboxylic acid of the formula R_2CO_2H or the corresponding acyl halide, wherein R_2 is as defined above, to form a compound of the Formula VI.

In another embodiment, a process (viii) comprises the above process (vii) further comprising the steps of:

providing a compound of Formula IV



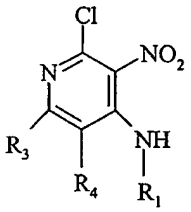
IV

wherein R_1, R_3 and R_4 are as defined above; and

reducing the compound of Formula IV to provide a compound of the Formula V.

In another embodiment, a process (ix) comprises the above process (viii) further comprising the steps of:

providing a compound of Formula III



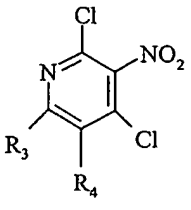
III

wherein R_1, R_3 and R_4 are as defined above; and

reacting the compound of Formula III with an alkali metal azide to provide a compound of the Formula IV. In one embodiment, the compound of Formula III is reacted with the alkali metal azide in the presence of cerium III chloride.

In another embodiment, a process (x) comprises the above process (ix) further comprising the steps of:

providing a compound of Formula II



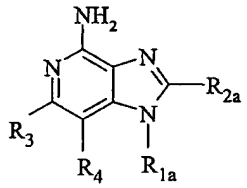
II

wherein R_3 and R_4 are as defined above; and

reacting the compound of Formula II with a compound of the formula R_1NH_2, wherein R_1 is as defined above, to provide a compound of the Formula III.

In another embodiment, the process (x) further comprises the step of isolating the compound of Formula I or a pharmaceutically acceptable salt thereof.

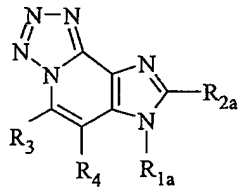
In one embodiment, the present invention provides a process (i-a) for preparing 1*H*-imidazo[4,5-*c*]pyridin-4-amine compounds of the Formula Ia



Ia

and pharmaceutically acceptable salts thereof, wherein R_{1a}, R_{2a}, R_3, and R_4 are as defined above, which process comprises the steps of:

providing a compound of Formula VIIa



VIIa

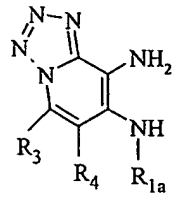
wherein R_{1a}, R_{2a}, R_3, and R_4 are as defined above; and

reductively removing the tetrazolo ring from the compound of Formula VIIa to provide a compound of the Formula Ia. In one embodiment, the tetrazolo ring is reductively removed by reacting a compound of Formula VIIa with hydrogen in the presence of a catalyst and an acid.

In another embodiment, the above process (i-a) further comprises the step of isolating the compound of Formula Ia or a pharmaceutically acceptable salt thereof.

In another embodiment, a process (ii-a) comprises the above process (i-a) further comprising the steps of:

providing a compound of Formula Va



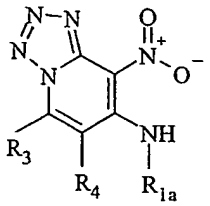
Va

wherein R_{1a}, R_3 and R_4 are as defined above; and

reacting a compound of the Formula Va with a carboxylic acid of the formula $R_{2a}CO_2H$; an equivalent thereof selected from the corresponding acyl halide, $R_{2a}C(O\text{-alkyl})_3$, and $R_{2a}C(O\text{-alkyl})_2(O(O{=})C\text{-alkyl})$; or a mixture thereof, wherein R_{2a} is as defined above, and each alkyl contains 1 to 8 carbon atoms, to provide a compound of the Formula VIIa.

In another embodiment, a process (iii-a) comprises the above process (ii-a) further comprising the steps of:

providing a compound of Formula IVa



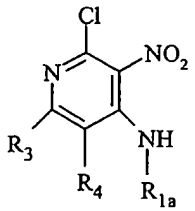
IVa

wherein R_{1a}, R_3 and R_4 are as defined above; and

reducing the compound of Formula IVa to provide a compound of the Formula Va.

In another embodiment, a process (iv-a) comprises the above process (iii-a) further comprising the steps of:

providing a compound of Formula IIIa



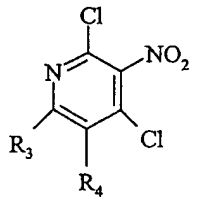
IIIa

wherein R_{1a}, R_3 and R_4 are as defined above; and

reacting the compound of Formula IIIa with an alkali metal azide to provide a compound of the Formula IVa. In another embodiment, the compound of Formula IIIa is reacted with the alkali metal azide in the presence of cerium III chloride.

In another embodiment, a process (v-a) comprises the above process (iv-a) further comprising the steps of:

providing a compound of Formula II



II

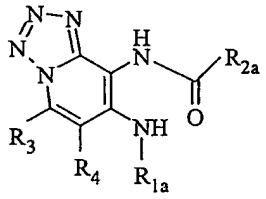
wherein R_3 and R_4 are as defined above; and

reacting the compound of Formula II with a compound of the formula $R_{1a}NH_2$, wherein R_{1a} is as defined above, to provide a compound of the Formula IIIa.

In another embodiment, the process (iv-a) further comprises the step of isolating the compound of Formula Ia or a pharmaceutically acceptable salt thereof.

In another embodiment, a process (vi-a) comprises the above process (i-a) further comprising the steps of:

providing a compound of Formula VIa



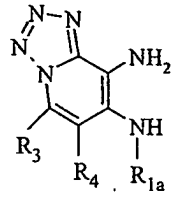
VIa

wherein R_{1a}, R_{2a}, R_3 and R_4 are as defined above; and

subjecting the compound of Formula VIa to cyclization conditions, to provide a compound of the Formula VIIa.

In another embodiment, a process (vii-a) comprises the above process (vi-a) further comprising the steps of:

providing a compound of Formula Va



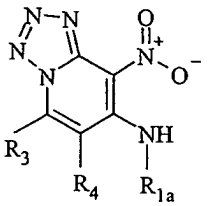
Va

wherein R_{1a}, R_3 and R_4 are as defined above; and

reacting a compound of the Formula Va with a carboxylic acid of the formula $R_{2a}CO_2H$ or the corresponding acyl halide, wherein R_{2a} is as defined above, to form a compound of the Formula VIa.

In another embodiment, a process (viii-a) comprises the above process (vii-a) further comprising the steps of:

providing a compound of Formula IVa



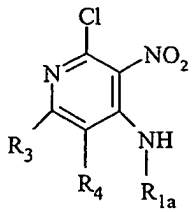
IVa

wherein R_{1a}, R_3 and R_4 are as defined above; and

reducing the compound of Formula IVa to provide a compound of the Formula Va.

In another embodiment, a process (ix-a) comprises the above process (viii-a) further comprising the steps of:

providing a compound of Formula IIIa



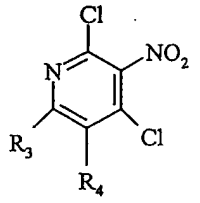
IIIa

wherein R_{1a}, R_3 and R_4 are as defined above; and

reacting the compound of Formula IIIa with an alkali metal azide to provide a compound of the Formula IVa. In another embodiment the compound of Formula IIIa is reacted with the alkali metal azide in the presence of cerium III chloride.

In another embodiment, a process (x-a) comprises the above process (ix-a) further comprising the steps of:

providing a compound of Formula II



II

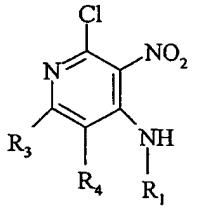
wherein R_3 and R_4 are as defined above; and

reacting the compound of Formula II with a compound of the formula $R_{1a}NH_2$, wherein R_{1a} is as defined above, to provide a compound of the Formula IIIa.

In another embodiment, the above process (ix-a) further comprises the step of isolating the compound of Formula Ia or a pharmaceutically acceptable salt thereof.

In one embodiment, the present invention provides a process (xi) for preparing a chemical compound comprising the steps of:

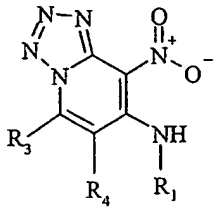
providing a compound of Formula III



III

wherein R_1, R_3 and R_4 are defined above; and

reacting the compound of Formula III with an alkali metal azide to provide a compound of Formula IV

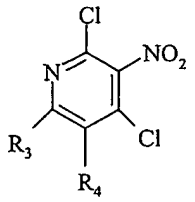


IV

wherein R_1, R_3, and R_4 are as defined above. In another embodiment, the compound of Formula III is reacted with the alkali metal azide in the presence of cerium III chloride.

In another embodiment, the process (xi) further comprises the steps of:

providing a compound of Formula II

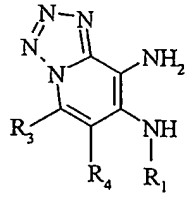


II

wherein R_3 and R_4 are as defined above; and

reacting the compound of Formula II with a compound of the formula R_1NH_2, wherein R_1 is as defined above, to provide a compound of Formula III.

In another embodiment, a process (xii) comprises the above process (xi) further comprising the step of reducing the compound of Formula IV to provide a compound of Formula V

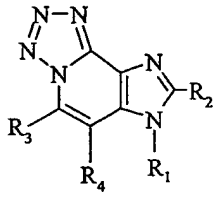


V

wherein R_1, R_3, and R_4 are as defined above.

In another embodiment, a process (xiii) comprises the above process (xii) further comprising the step of reacting a compound of Formula V with a carboxylic acid of the formula R_2CO_2H; an equivalent thereof selected from the corresponding acyl halide, $R_2C(O\text{-alkyl})_3$, and $R_2C(O\text{-alkyl})_2(O(O=)C\text{-alkyl})$; or a mixture thereof,

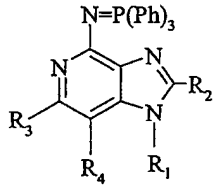
wherein each alkyl contains 1 to 8 carbon atoms; and R_2 is as defined above; to provide a compound of the Formula VII



VII

wherein R_1, R_2, R_3, and R_4 are as defined above.

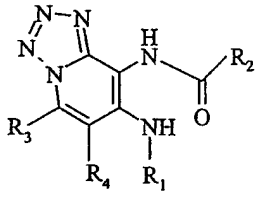
In another embodiment, a process (xiv) comprises the above process (xiii) further comprising the step of reacting the compound of Formula VII with triphenylphosphine to provide an *N*-triphenylphosphinyl intermediate of Formula VIII



VIII

wherein R_1, R_2, R_3, and R_4 are as defined above.

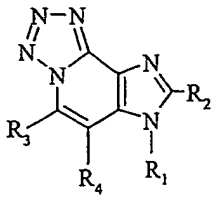
In another embodiment, a process (xv) comprises the above process (xii) further comprising the step of (a) reacting the compound of Formula V with a carboxylic acid of the formula R_2CO_2H or the corresponding acyl halide to form a compound of the Formula VI



VI

wherein R_1, R_2, R_3, and R_4 are as defined above.

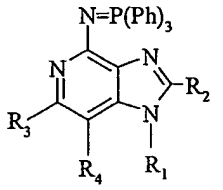
In another embodiment, a process (xvi) comprises the above process (xv) further comprising the step of (b) subjecting the compound of Formula VI to cyclization conditions, during step (a) or subsequent to the completion of step (a), to provide a compound of the Formula VII



VII

wherein R_1, R_2, R_3, and R_4 are as defined above.

In another embodiment, a process (xvii) comprises the above process (xvi) further comprising the step of reacting the compound of Formula VII with triphenylphosphine to provide an *N*-triphenylphosphinyl intermediate of Formula VIII



VIII

wherein R_1, R_2, R_3, and R_4 are as defined above.

In some embodiments, R_1, R_2, R_3, and R_4 in the above processes (i), (ii), (iii), (iv), (v), (vi), (vii), (viii), (ix), (x), (xi), (xii), (xiii), (xiv), (xv), (xvi), (xvii), (i-a), (ii-a), (iii-a), (iv-a), (v-a), (vi-a), (vii-a), (viii-a), (ix-a), and (x-a) are independently selected as follows: R_1 is selected from alkyl of one to four carbon atoms, alkenyl of two to four carbon atoms, hydroxyalkyl of one to four carbon atoms, alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to four carbon atoms, and phenylethyl; R_2 and R_{2a} are selected from alkyl of one to four carbon atoms, hydroxyalkyl of one to four carbon atoms, and alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to four carbon atoms; and R_3 and R_4 are independently selected from hydrogen and alkyl of one to four carbon atoms. In certain embodiments, R_1 is selected from *n*-butyl, 2-methylpropyl, 2-methyl-1-propenyl, 2-hydroxy-2-methylpropyl, 2-ethoxyethyl, and 2-phenylethyl; R_2 and R_{2a} are selected from methyl, ethyl, propyl, butyl, hydroxymethyl, 2-methoxyethyl, and ethoxymethyl; R_3 is methyl; and R_4 is selected from hydrogen and methyl. In certain embodiments, R_1 is selected from 2-hydroxy-2-methylpropyl, 2-methylpropyl, and n-butyl. In certain embodiments, R_4 is methyl.

In some embodiments, R_{1a} in the above processes (i-a), (ii-a), (iii-a), (iv-a), (v-a), (vi-a), (vii-a), (viii-a), (ix-a), and (x-a) is independently selected from alkyl of one to four carbon atoms, hydroxyalkyl of one to four carbon atoms, and alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to four carbon atoms. In certain embodiments, R_{1a} is selected from *n*-butyl, 2-methylpropyl, 2-hydroxy-2-methylpropyl, and 2-ethoxyethyl.

In other embodiments, the above processes (ii), (iii), (iv), (v), (xiii), and (xiv), wherein the compound of Formula V is reacted with a carboxylic acid of the formula R_2CO_2H; an equivalent thereof selected from the corresponding acyl halide, $R_2C(O\text{-alkyl})_3$, and $R_2C(O\text{-alkyl})_2(O(O=)C\text{-alkyl})$; or a mixture thereof; and wherein R_2 is as defined above, are done in the presence of cyclization conditions to provide a compound of the Formula VII.

In other embodiments, the above processes (ii-a), (iii-a), (iv-a), and (v-a), wherein the compound of Formula Va is reacted with a carboxylic acid of the formula $R_{2a}CO_2H$; an equivalent thereof selected from the corresponding acyl halide, $R_{2a}C(O\text{-alkyl})_3$, and $R_{2a}C(O\text{-alkyl})_2(O(O=)C\text{-alkyl})$; or a mixture thereof; and wherein R_{2a} is as defined above, are done in the presence of cyclization conditions to provide a compound of the Formula VIIa.

In other embodiments, the alkali metal azide in the above processes (iv), (v), (ix), (x), (iv-a), (v-a), (ix-a), (x-a), (xi), (xii), (xiii), (xiv), (xv), (xvi), (xvii), and (xviii) is sodium azide.

In other embodiments, the compound of Formula IV or IVa is reduced with a heterogeneous hydrogenation catalyst in the above processes (iii), (iv), (v), (viii), (ix), (x), (iii-a), (iv-a), (v-a), (viii-a), (ix-a), (x-a), (xii), (xiii), (xiv), (xv), (xvi), (xvii), and (xviii).

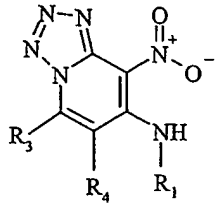
In other embodiments, in the above processes (vii), (viii), (ix), (x), (vii-a), (viii-a), (ix-a), (x-a), (xvi), and (xvii) the compound of Formula V is reacted with the corresponding acyl halide to form the compound of Formula VI, and the compound of Formula VI is subjected to cyclization conditions which include an elevated temperature and the presence of pyridine hydrochloride. In certain embodiments, the acyl halide is ethoxyacetyl chloride.

In some embodiments, in the above processes (i), (ii), (iii), (iv), (v), (vi), (vii), (viii), (ix), (x), (i-a), (ii-a), (iii-a), (iv-a), (v-a), (vi-a), (vii-a), (viii-a), (ix-a), and (x-a) the

compound of Formula I or Ia is 2-(ethoxymethyl)-1-(2-methylpropyl)-6-methyl-1*H*-imidazo[4,5-*c*]pyridin-4-amine.

In another aspect, the invention provides novel compounds useful as intermediates in the preparation of the compounds of Formulas I and Ia. These intermediates have the structural Formulas IV-VII.

One class of intermediate compounds has the Formula IV:



IV

wherein

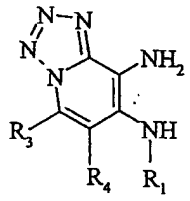
R_1 is selected from the group consisting of hydrogen; CHR_xR_y wherein R_x is hydrogen and R_y is selected from the group consisting of alkyl or cyclic alkyl containing one to ten carbon atoms, alkenyl containing two to ten carbon atoms, hydroxyalkyl containing one to six carbon atoms, alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon atoms, benzyl, and phenylethyl; and $-C=CR_zR_z$ wherein each R_z is independently alkyl or cyclic alkyl of one to six carbon atoms; and

R_3 and R_4 are independently selected from the group consisting of hydrogen and alkyl of one to five carbon atoms.

In some embodiments, R_1 is selected from alkyl of one to four carbon atoms, alkenyl of two to four carbon atoms, hydroxyalkyl of one to four carbon atoms, alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to four carbon atoms, and phenylethyl; and R_3 and R_4 are independently selected from hydrogen and alkyl of one to four carbon atoms.

In some embodiments, R_1, R_3, and R_4 are independently selected as follows: R_1 is selected from *n*-butyl, 2-methylpropyl, 2-methyl-1-propenyl, 2-hydroxy-2-methylpropyl, 2-ethoxyethyl, and 2-phenylethyl; R_3 is methyl, and R_4 is selected from hydrogen and methyl. In some preferred embodiments, R_3 and R_4 are methyl.

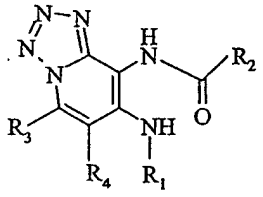
Another class of intermediate compounds has the Formula V



V

wherein R_1, R_3 and R_4 are selected as described above for intermediate compounds of the Formula IV.

Another class of intermediate compounds has the Formula VI



VI

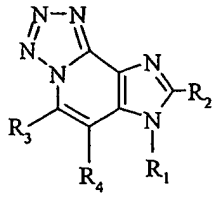
wherein R_1, R_3 and R_4 are selected as described above for intermediate compounds of the Formula IV, and

R_2 is selected from the group consisting of hydrogen; alkyl containing one to eight carbon atoms; hydroxyalkyl containing one to six carbon atoms; alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon atoms; benzyl; phenylethyl; phenyl; the benzyl, phenylethyl, or phenyl substituent being optionally substituted on the benzene ring by a moiety selected from the group consisting of methyl, methoxy, and halogen; and morpholinoalkyl wherein the alkyl moiety contains one to four carbon atoms.

In some embodiments, R_2 is selected from alkyl of one to four carbon atoms, hydroxyalkyl of one to four carbon atoms, and alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to four carbon atoms.

In some embodiments, R_2 is selected from methyl, ethyl, propyl, butyl, hydroxymethyl, 2-methoxyethyl, and ethoxymethyl.

Another class of intermediate compounds has the Formula VII



VII

wherein R_1, R_2, R_3, and R_4 are selected as described above for the intermediate compound of the Formula VI, and wherein when R_1 is hydrogen, at least one of R_2, R_3, or R_4 is other than hydrogen.

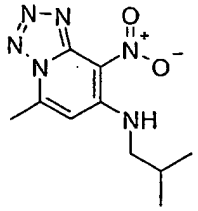
The processes of the invention are useful for making compounds and salts of Formulas I and Ia, or for making intermediates which are useful for making such compounds and salts. Compounds and salts of Formulas I and Ia are disclosed in U.S. Pat. No. 5,446,153 as having immunomodulating activity, including, for example, inducing the biosynthesis of interferon, and exhibiting antiviral and antituor activity.

Various aspects and embodiments of the invention are further described by the Examples, which are provided for illustration purposes only and are not intended to be limiting in any way.

EXAMPLES

Example 1

N-(2-Methylpropyl)-5-methyl-8-nitrotetraazolo[1,5-*a*]pyridin-7-amine



Part A

Under a nitrogen atmosphere, a solution of 2,4-dichloro-6-methyl-3-nitropyridine (125 g, 0.604 mol) in anhydrous *N,N*-dimethylformamide (625 mL) was cooled to 0 °C. Triethylamine (84.2 mL, 0.604 mol) was added. 2-Methylpropylamine (66 mL, 0.664 mol) was added dropwise to the resulting solution over a period of one hour; the reaction reached a temperature of 17 °C and became yellow. The reaction was allowed to warm to

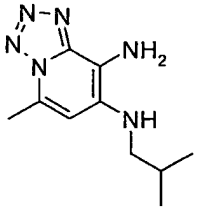
room temperature and stir overnight. The reaction mixture was filtered to remove salts, and then the *N*,*N*-dimethylformamide was removed under reduced pressure. The crude product was dissolved in ethyl acetate (750 mL), and the solution was washed with water (3 x 1L), dried over magnesium sulfate, and then concentrated under reduced pressure. Hexane (300 mL) was added to the resulting yellow oil; the mixture was heated until the oil dissolved and then placed in a freezer. After ten minutes, the recrystallization mixture was seeded with crystals made in a previous run and then left undisturbed for four hours. The resulting precipitate was filtered, washed with cold hexane, and dried in a vacuum oven at room temperature to provide 98 g of 2-chloro-*N*-(2-methylpropyl)-6-methyl-3-nitropyridin-4-amine.

Part B

Under a nitrogen atmosphere, a mixture of 2-chloro-*N*-(2-methylpropyl)-6-methyl-3-nitropyridin-4-amine (10.0 g, 41.0 mmol), sodium azide (2.67 g, 41.0 mmol), and anhydrous *N*,*N*-dimethylformamide (200 mL) was heated at 60 °C. After 5 hours, the dark green solution was allowed to cool to room temperature, poured slowly into water (2 L), and stirred for fifteen minutes. A green precipitate formed, which was filtered and washed with water to yield 9.37 g of *N*-(2-methylpropyl)-5-methyl-8-nitrotetraazolo[1,5-*a*]pyridin-7-amine as a light green solid, m.p. 185-187 °C.

Example 2

N^7-(2-Methylpropyl)-5-methyltetraazolo[1,5-*a*]pyridine-7,8-diamine

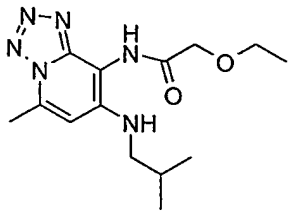


N-(2-Methylpropyl)-5-methyl-8-nitrotetraazolo[1,5-*a*]pyridin-7-amine (9.60 g, 43.6 mmol) was dissolved in warm anhydrous toluene (900 mL) and methanol (100 mL) and then added to a 2 L stainless steel Parr vessel. The vessel was flushed several times with nitrogen, and 5% platinum on carbon (2.0 g) was added to the solution. The vessel was flushed multiple times with hydrogen, and then placed under hydrogen pressure (50

psi, 3.4 x 10^5 Pa). After two hours, no further hydrogen was consumed. The reaction mixture was filtered through a layer of filter agent (available from Aldrich, Milwaukee, WI under the trade name CELITE), and the filter cake was washed with hot toluene (1 L). The filtrate was concentrated under reduced pressure to yield 8.5 g N^7-(2-methylpropyl)-5-methyltetraazolo[1,5-*a*]pyridine-7,8-diamine as a light orange solid, m. p. 159-162 °C.

Example 3

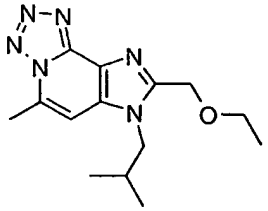
2-Ethoxy-*N*-{7-[(2-methylpropyl)amino]-5-methyltetraazolo[1,5-*a*]pyridin-8-yl}acetamide



A mixture of N^7-(2-methylpropyl)-5-methyltetraazolo[1,5-*a*]pyridine-7,8-diamine (8.4 g, 38.1 mmol) in anhydrous dichloromethane (300 mL) was cooled to 0 °C under a nitrogen atmosphere, and triethylamine (5.3 mL, 38.1 mmol) was added. A solution of ethoxyacetyl chloride (4.7 g, 38.1 mmol) in dichloromethane (100 mL) was added dropwise over a period of five minutes, and a homogeneous solution resulted. After the solution was stirred for one hour, it was allowed to warm to room temperature, washed with water (2 x 200 mL), dried over magnesium sulfate, filtered, and concentrated under reduced pressure to provide 11.2 g of 2-ethoxy-*N*-{7-[(2-methylpropyl)amino]-5-methyltetraazolo[1,5-*a*]pyridin-8-yl}acetamide as a light tan solid, m. p. 182-185 °C.

Example 4

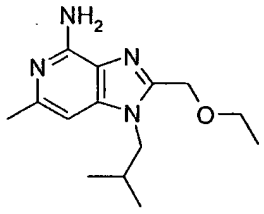
8-(Ethoxymethyl)-7-(2-methylpropyl)-5-methyl-7*H*-imidazo[4,5-*c*]tetraazolo[1,5-*a*]pyridine



A solution of 2-ethoxy-*N*-{7-[(2-methylpropyl)amino]-5-methyltetraazolo[1,5-*a*]pyridin-8-yl}acetamide (10.9 g, 35.6 mmol) and pyridine hydrochloride (10 g) in pyridine (100 mL) was heated at reflux under a nitrogen atmosphere for five days. An analysis by high-performance liquid chromatography indicated the presence of 16% starting material, and an additional 10 g of pyridine hydrochloride was added. After a total of seven days, the reaction was complete, and the solvent was removed under reduced pressure. The resulting black oil was dissolved in ethyl acetate (500 mL), and the solution was washed with water (3 x 200 mL), dried over magnesium sulfate, filtered, and concentrated to 200 mL. Needles began to form in the solution, which was placed in a freezer for two hours. The crystals were then filtered and washed with cold ethyl acetate to yield 6.85 g of 8-(ethoxymethyl)-7-(2-methylpropyl)-5-methyl-7*H*-imidazo[4,5-*c*]tetraazolo[1,5-*a*]pyridine as light brown needles, m. p. 158-160 °C.

Example 5

2-(Ethoxymethyl)-1-(2-methylpropyl)-6-methyl-1*H*-imidazo[4,5-*c*]pyridin-4-amine hydrochloride

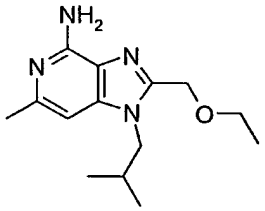


A mixture of 8-(ethoxymethyl)-7-(2-methylpropyl)-5-methyl-7*H*-imidazo[4,5-*c*]tetraazolo[1,5-*a*]pyridine (6.5 g, 22.5 mmol), triphenylphosphine (6.5 g, 24.8 mmol), and toluene (130 mL) was stirred and heated at reflux under nitrogen for 24 hours. Additional triphenylphosphine (3.0 g, 11.4 mmol) was added to the cloudy mixture, and the reaction was continued for three days. The solvent was removed under reduced pressure, and the resulting brown oil was dissolved in methanol (100mL). Following the addition of a 1.0 M solution of hydrochloric acid in diethyl ether (45mL) to the methanol solution, the reaction was heated at reflux overnight. The solvents were removed under reduced pressure, and water (200 mL) was added to the resulting brown oil, forming a white precipitate that was removed by filtration. Solid sodium carbonate (6.5 g) was added to the aqueous solution, followed by extraction with dichloromethane (2 x 200 mL).

The combined extracts were dried over magnesium sulfate, filtered, and concentrated under reduced pressure to provide a brown oil, which was dissolved in 2-propanol (45 mL). A 1.0 M solution of hydrochloric acid in diethyl ether (22.5 mL) was added to the solution of crude product, and a white solid formed. After one hour the solid was isolated by filtration, washed with cold 2-propanol and diethyl ether, and dried in a vacuum oven at 90 °C for two days to yield 4.3 g of 2-(ethoxymethyl)-1-(2-methylpropyl)-6-methyl-1*H*-imidazo[4,5-*c*]pyridin-4-amine hydrochloride as a white solid, m. p. 181-183 °C. Analysis: Calculated for $C_{14}H_{22}N_4O \cdot HCl$: %C, 56.27; %H, 7.76; %N, 18.75. Found: %C, 56.33; %H, 7.67; %N, 18.90.

Example 6

2-(Ethoxymethyl)-1-(2-methylpropyl)-6-methyl-1*H*-imidazo[4,5-*c*]pyridin-4-amine

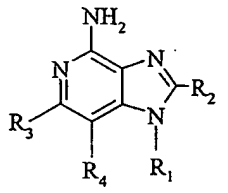


8-(Ethoxymethyl)-7-(2-methylpropyl)-5-methyl-7*H*-imidazo[4,5-*c*]tetraazolo[1,5-*a*]pyridine (6.5 g, 22.5 mmol), trifluoroacetic acid (67 mL), and platinum (IV) oxide (0.47 g) are added to a stainless steel Parr vessel, which is then placed under hydrogen pressure (50 psi, 3.4 x 10^5 Pa). For the first eight hours, the vessel is flushed with hydrogen every two hours and then maintained under hydrogen pressure (50 psi, 3.4 x 10^5 Pa) overnight. The reaction mixture is filtered through a layer of CELITE filter aid, and the filter cake is washed with additional trifluoroacetic acid. The filtrate is concentrated under reduced pressure to yield a light brown oil, which is dissolved in 37% aqueous hydrochloric acid (25 mL). Sodium carbonate is added to this solution until it exhibits pH 12. The resulting solution is extracted with chloroform. The chloroform solution is dried over magnesium sulfate, filtered, and concentrated under reduced pressure to provide about 4 g of 2-(ethoxymethyl)-1-(2-methylpropyl)-6-methyl-1*H*-imidazo[4,5-*c*]pyridin-4-amine as a white solid.

The complete disclosures of the patents, patent documents, and publications cited herein are incorporated by reference in their entirety as if each were individually incorporated. Various modifications and alterations to this invention will become apparent to those skilled in the art without departing from the scope and spirit of this invention. It should be understood that this invention is not intended to be unduly limited by the illustrative embodiments and examples set forth herein and that such examples and embodiments are presented by way of example only with the scope of the invention intended to be limited only by the claims set forth herein as follows.

What is Claimed is:

1. A process for preparing 1*H*-imidazo[4,5-*c*]pyridin-4-amine compounds of the Formula I



I

and pharmaceutically acceptable salts thereof wherein

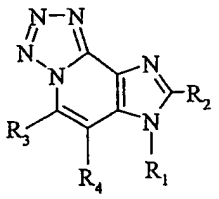
R_1 is selected from the group consisting of hydrogen; CHR_xR_y wherein R_x is hydrogen and R_y is selected from the group consisting of alkyl or cyclic alkyl containing one to ten carbon atoms, alkenyl containing two to ten carbon atoms, hydroxyalkyl containing one to six carbon atoms, alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon atoms, benzyl, and phenylethyl; and $-C=CR_zR_z$ wherein each R_z is independently alkyl or cyclic alkyl of one to six carbon atoms;

R_2 is selected from the group consisting of hydrogen; alkyl containing one to eight carbon atoms; hydroxyalkyl containing one to six carbon atoms; alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon atoms; benzyl; phenylethyl; phenyl; the benzyl, phenylethyl, or phenyl substituent being optionally substituted on the benzene ring by a moiety selected from the group consisting of methyl, methoxy, and halogen; and morpholinoalkyl wherein the alkyl moiety contains one to four carbon atoms; and

R_3 and R_4 are independently selected from the group consisting of hydrogen and alkyl of one to five carbon atoms,

which process comprises the steps of:

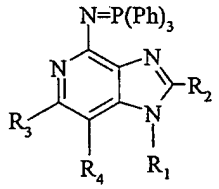
providing a compound of the Formula VII



VII

wherein R_1, R_2, R_3 and R_4 are as defined above;

reacting the compound of Formula VII with triphenylphosphine to provide an *N*-triphenylphosphinyl intermediate of Formula VIII



VIII

wherein R_1, R_2, R_3 and R_4 are as defined above; and

hydrolyzing the *N*-triphenylphosphinyl intermediate of Formula VIII to provide a compound of Formula I.

2. The process of claim 1, further comprising the step of isolating the compound of Formula I or a pharmaceutically acceptable salt thereof.

3. The process according to claim 1, wherein R_1 is selected from alkyl of one to four carbon atoms, alkenyl of two to four carbon atoms, hydroxyalkyl of one to four carbon atoms, alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to four carbon atoms, and phenylethyl.

4. The process according to claim 3, wherein R_1 is selected from 2-hydroxy-2-methylpropyl, 2-methylpropyl, and *n*-butyl.

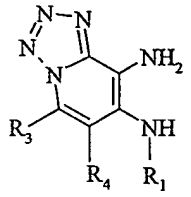
5. The process according to claim 1, wherein R_2 is selected from alkyl of one to four carbon atoms, hydroxyalkyl of one to four carbon atoms, and alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to four carbon atoms.

6. The process according to claim 5, wherein R_2 is selected from methyl, ethyl, propyl, butyl, hydroxymethyl, 2-methoxyethyl, and ethoxymethyl.

7. The process according to claim 1, wherein R_3 is methyl, and R_4 is hydrogen or methyl.

8. The process of claim 1, further comprising the steps of:

providing a compound of Formula V



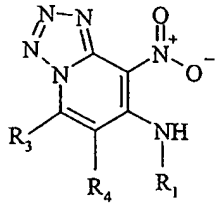
V

wherein R_1, R_3 and R_4 are as defined in claim 1; and

reacting a compound of the Formula V with a carboxylic acid of the formula R_2CO_2H; an equivalent thereof selected from the corresponding acyl halide, $R_2C(O\text{-alkyl})_3$, and $R_2C(O\text{-alkyl})_2(O(O{=})C\text{-alkyl})$; or a mixture thereof, wherein R_2 is as defined in claim 1, and each alkyl contains 1 to 8 carbon atoms, to provide a compound of the Formula VII.

9. The process of claim 8, further comprising the steps of:

providing a compound of Formula IV



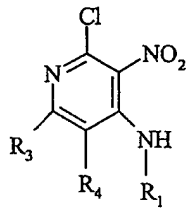
IV

wherein R_1, R_3 and R_4 are as described in claim 8; and

reducing the compound of Formula IV to provide a compound of the Formula V.

10. The process of claim 9, further comprising the steps of:

providing a compound of Formula III



III

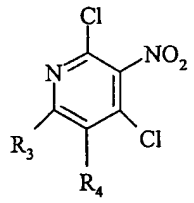
wherein R_1, R_3 and R_4 are as described in claim 9; and

reacting the compound of Formula III with an alkali metal azide to provide a compound of the Formula IV.

11. The process according to claim 10, wherein the compound of Formula III is reacted with the alkali metal azide in the presence of cerium III chloride.

12. The process of claim 10, further comprising the steps of:

providing a compound of Formula II



II

wherein R_3 and R_4 are as described in claim 10; and

reacting the compound of Formula II with a compound of the formula R_1NH_2, wherein R_1 is as defined in claim 10, to provide a compound of the Formula III.

13. The process of claim 10, further comprising the step of isolating the compound of Formula I or a pharmaceutically acceptable salt thereof.

14. The process according to claim 10, wherein R_1, R_2, R_3, and R_4 are independently selected as follows:

R_1 is selected from alkyl of one to four carbon atoms, alkenyl of two to four carbon atoms, hydroxyalkyl of one to four carbon atoms, alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to four carbon atoms, and phenylethyl;

R_2 is selected from alkyl of one to four carbon atoms, hydroxyalkyl of one to four carbon atoms, and alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to four carbon atoms;

R_3 is selected from hydrogen and alkyl of one to four carbon atoms; and

R_4 is selected from hydrogen and alkyl of one to four carbon atoms.

15. The process according to claim 14, wherein R_1, R_2, R_3, and R_4 are independently selected as follows:

R_1 is selected from 2-hydroxy-2-methylpropyl, 2-methylpropyl, and *n*-butyl;

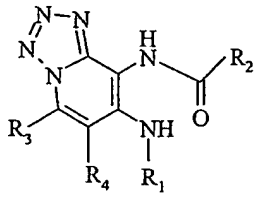
R_2 is selected from methyl, ethyl, propyl, butyl, hydroxymethyl, 2-methoxyethyl, and ethoxymethyl;

R_3 is methyl; and

R_4 is selected from hydrogen and methyl.

16. The process of claim 1, further comprising the steps of:

providing a compound of Formula VI



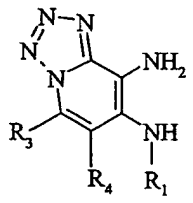
VI

wherein R_1, R_2, R_3 and R_4 are as defined in claim 1; and

subjecting the compound of Formula VI to cyclization conditions, to provide a compound of the Formula VII.

17. The process of claim 16, further comprising the steps of:

providing a compound of Formula V



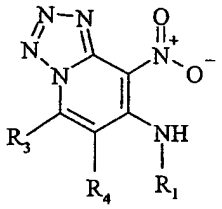
V

wherein R_1, R_3 and R_4 are as defined in claim 16; and

reacting a compound of the Formula V with a carboxylic acid of the formula R_2CO_2H or the corresponding acyl halide, wherein R_2 is as defined in claim 16, to form a compound of the Formula VI.

18. The process of claim 17, further comprising the steps of:

providing a compound of Formula IV



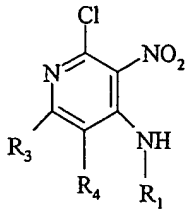
IV

wherein R_1, R_3 and R_4 are as described in claim 17; and

reducing the compound of Formula IV to provide a compound of the Formula V.

19. The process of claim 18, further comprising the steps of:

providing a compound of Formula III



III

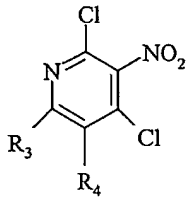
wherein R_1, R_3 and R_4 are as described in claim 18; and

reacting the compound of Formula III with an alkali metal azide to provide a compound of the Formula IV.

20. The process according to claim 19, wherein the compound of Formula III is reacted with the alkali metal azide in the presence of cerium III chloride.

21. The process of claim 19, further comprising the steps of:

providing a compound of Formula II



II

wherein R_3 and R_4 are as described in claim 19; and

reacting the compound of Formula II with a compound of the formula R_1NH_2, wherein R_1 is as defined in claim 19, to provide a compound of the Formula III.

22. The process of claim 19, further comprising the step of isolating the compound of Formula I or a pharmaceutically acceptable salt thereof.

23. The process according to claim 19, wherein R_1, R_2, R_3, and R_4 are independently selected as follows:

R_1 is selected from alkyl of one to four carbon atoms, alkenyl of two to four carbon atoms, hydroxyalkyl of one to four carbon atoms, alkoxyalkyl wherein the alkoxy moiety

contains one to four carbon atoms and the alkyl moiety contains one to four carbon atoms, and phenylethyl;

R_2 is selected from alkyl of one to four carbon atoms, hydroxyalkyl of one to four carbon atoms, and alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to four carbon atoms;

R_3 is selected from hydrogen and alkyl of one to four carbon atoms; and

R_4 is selected from hydrogen and alkyl of one to four carbon atoms.

24. The process according to claim 23, wherein R_1, R_2, R_3, and R_4 are independently selected as follows:

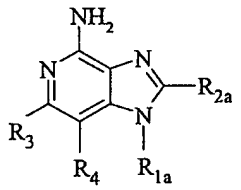
R_1 is selected from 2-hydroxy-2-methylpropyl, 2-methylpropyl, and *n*-butyl;

R_2 is selected from methyl, ethyl, propyl, butyl, hydroxymethyl, 2-methoxyethyl, and ethoxymethyl;

R_3 is methyl; and

R_4 is selected from hydrogen and methyl.

25. A process for preparing 1*H*-imidazo[4,5-*c*]pyridin-4-amine compounds of the Formula Ia



Ia

and pharmaceutically acceptable salts thereof, wherein R_{1a} is selected from hydrogen and CHR_xR_y wherein R_x is hydrogen and R_y is selected from alkyl or cyclic alkyl containing one to ten carbon atoms, hydroxyalkyl containing one to six carbon atoms, alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon;

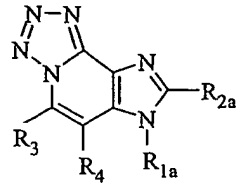
R_{2a} is selected from hydrogen; alkyl containing one to eight carbon atoms; hydroxyalkyl containing one to six carbon atoms; and alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon

atoms; and morpholinoalkyl wherein the alkyl moiety contains one to four carbon atoms; and

R_3 and R_4 are independently selected from hydrogen and alkyl of one to five carbon atoms;

which process comprises the steps of:

providing a compound of Formula VIIa



VIIa

wherein R_{1a}, R_{2a}, R_3, and R_4 are as defined above; and

reductively removing the tetrazolo ring from the compound of Formula VIIa to provide a compound of the Formula Ia.

26. The process according to claim 25, wherein the tetrazolo ring is reductively removed by reacting a compound of Formula VIIa with hydrogen in the presence of a catalyst and an acid.

27. The process of claim 25, further comprising the step of isolating the compound of Formula Ia or a pharmaceutically acceptable salt thereof.

28. The process according to claim 25, wherein R_{1a} is selected from alkyl of one to four carbon atoms, hydroxyalkyl of one to four carbon atoms, and alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to four carbon atoms.

29. The process according to claim 28, wherein R_{1a} is selected from 2-hydroxy-2-methylpropyl, 2-methylpropyl, and *n*-butyl.

30. The process according to claim 25, wherein R_{2a} is selected from alkyl of one to four carbon atoms, hydroxyalkyl of one to four carbon atoms, and alkoxyalkyl wherein the

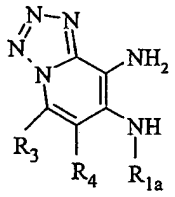
alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to four carbon atoms.

31. The process according to claim 30, wherein R_{2a} is selected from methyl, ethyl, propyl, butyl, hydroxymethyl, 2-methoxyethyl, and ethoxymethyl.

32. The process according to claim 25, wherein R_3 is methyl, and R_4 is hydrogen or methyl.

33. The process of claim 25, further comprising the steps of:

providing a compound of Formula Va



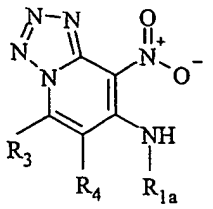
Va

wherein R_{1a}, R_3 and R_4 are as defined in claim 25; and

reacting a compound of the Formula Va with a carboxylic acid of the formula $R_{2a}CO_2H$; an equivalent thereof selected from the corresponding acyl halide, $R_{2a}C(O\text{-alkyl})_3$, and $R_{2a}C(O\text{-alkyl})_2(O(O{=})C\text{-alkyl})$; or a mixture thereof, wherein R_{2a} is as defined in claim 25, and each alkyl contains 1 to 8 carbon atoms, to provide a compound of the Formula VIIa.

34. The process of claim 33, further comprising the steps of:

providing a compound of Formula IVa



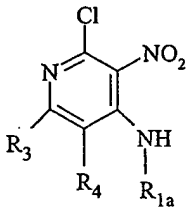
IVa

wherein R_{1a}, R_3 and R_4 are as described in claim 33; and

reducing the compound of Formula IVa to provide a compound of the Formula Va.

35. The process of claim 34, further comprising the steps of:

providing a compound of Formula IIIa



IIIa

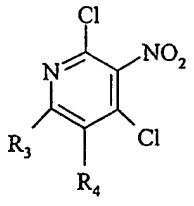
wherein R_{1a}, R_3 and R_4 are as described in claim 34; and

reacting the compound of Formula IIIa with an alkali metal azide to provide a compound of the Formula IVa.

36. The process according to claim 35, wherein the compound of Formula IIIa is reacted with the alkali metal azide in the presence of cerium III chloride.

37. The process of claim 35, further comprising the steps of:

providing a compound of Formula II



II

wherein R_3 and R_4 are as described in claim 35; and

reacting the compound of Formula II with a compound of the formula $R_{1a}NH_2$, wherein R_{1a} is as defined in claim 35, to provide a compound of the Formula IIIa.

38. The process of claim 35, further comprising the step of isolating the compound of Formula Ia or a pharmaceutically acceptable salt thereof.

39. The process according to claim 35, wherein R_{1a}, R_{2a}, R_3, and R_4 are independently selected as follows:

R_{1a} is selected from alkyl of one to four carbon atoms, hydroxyalkyl of one to four carbon atoms, and alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to four carbon atoms;

R_{2a} is selected from alkyl of one to four carbon atoms, hydroxyalkyl of one to four carbon atoms, and alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to four carbon atoms;

R_3 is selected from hydrogen and alkyl of one to four carbon atoms; and

R_4 is selected from hydrogen and alkyl of one to four carbon atoms.

40. The process according to claim 39, wherein R_{1a}, R_{2a}, R_3, and R_4 are independently selected as follows:

R_{1a} is selected from 2-hydroxy-2-methylpropyl, 2-methylpropyl, and *n*-butyl;

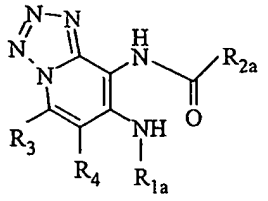
R_{2a} is selected from methyl, ethyl, propyl, butyl, hydroxymethyl, 2-methoxyethyl, and ethoxymethyl;

R_3 is methyl; and

R_4 is selected from hydrogen and methyl.

41. The process of claim 25, further comprising the steps of:

providing a compound of Formula VIa



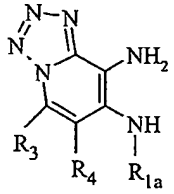
VIa

wherein R_{1a}, R_{2a}, R_3 and R_4 are as defined in claim 25; and

subjecting the compound of Formula VIa to cyclization conditions, to provide a compound of the Formula VIIa.

42. The process of claim 41, further comprising the steps of:

providing a compound of Formula Va



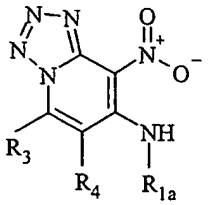
Va

wherein R_{1a}, R_3 and R_4 are as defined in claim 41; and

reacting a compound of the Formula Va with a carboxylic acid of the formula $R_{2a}CO_2H$ or the corresponding acyl halide, wherein R_{2a} is as defined in claim 41, to form a compound of the Formula VIa.

43. The process of claim 42, further comprising the steps of:

providing a compound of Formula IVa



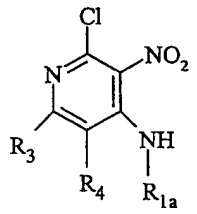
IVa

wherein R_{1a}, R_3 and R_4 are as described in claim 42; and

reducing the compound of Formula IVa to provide a compound of the Formula Va.

44. The process of claim 43, further comprising the steps of:

providing a compound of Formula IIIa



IIIa

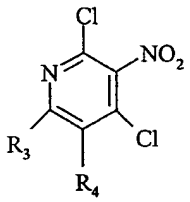
wherein R_{1a}, R_3 and R_4 are as described in claim 43; and

reacting the compound of Formula IIIa with an alkali metal azide to provide a compound of the Formula IVa.

45. The process according to claim 44, wherein the compound of Formula IIIa is reacted with the alkali metal azide in the presence of cerium III chloride.

46. The process of claim 44, further comprising the steps of:

providing a compound of Formula II



II

wherein R_3 and R_4 are as described in claim 44; and

reacting the compound of Formula II with a compound of the formula $R_{1a}NH_2$, wherein R_{1a} is as defined in claim 44, to provide a compound of the Formula IIIa.

47. The process of claim 44, further comprising the step of isolating the compound of Formula Ia or a pharmaceutically acceptable salt thereof.

48. The process according to claim 44, wherein R_{1a}, R_{2a}, R_3, and R_4 are independently selected as follows:

R_{1a} is selected from alkyl of one to four carbon atoms, hydroxyalkyl of one to four carbon atoms, and alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to four carbon atoms;

R_{2a} is selected from alkyl of one to four carbon atoms, hydroxyalkyl of one to four carbon atoms, and alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to four carbon atoms;

R_3 is selected from hydrogen and alkyl of one to four carbon atoms; and

R_4 is selected from hydrogen and alkyl of one to four carbon atoms.

49. The process according to claim 48, wherein R_{1a}, R_{2a}, R_3, and R_4 are independently selected as follows:

R_1 is selected from 2-hydroxy-2-methylpropyl, 2-methylpropyl, and *n*-butyl;

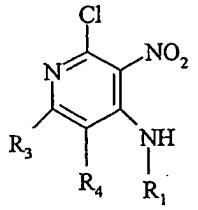
R_2 is selected from methyl, ethyl, propyl, butyl, hydroxymethyl, 2-methoxyethyl, and ethoxymethyl;

R_3 is methyl; and

R_4 is selected from hydrogen and methyl.

50. A process for preparing a chemical compound comprising the steps of:

providing a compound of Formula III



III

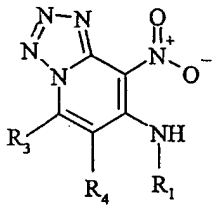
wherein

R_3 and R_4 are independently selected from hydrogen and alkyl of one to five carbon atoms, and

R_1 is selected from hydrogen; CHR_xR_y wherein R_x is hydrogen and R_y is selected from alkyl or cyclic alkyl containing one to ten carbon atoms, alkenyl containing two to ten carbon atoms, hydroxyalkyl containing one to six carbon atoms, alkoxyalkyl wherein

the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon atoms, benzyl, and phenylethyl; and $-C=CR_zR_z$ wherein each R_z is independently alkyl or cyclic alkyl of one to six carbon atoms; and

reacting the compound of Formula III with an alkali metal azide to provide a compound of Formula IV



IV

wherein R_1, R_3, and R_4 are as defined above.

51. The process according to claim 50, wherein the compound of Formula III is reacted with the alkali metal azide in the presence of cerium III chloride.

52. The process according to claim 50, wherein R_1, R_3, and R_4 are independently selected as follows:

R_1 is selected from alkyl of one to four carbon atoms, hydroxyalkyl of one to four carbon atoms, alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to four carbon atoms, and phenylethyl;

R_3 is selected from hydrogen and alkyl of one to four carbon atoms; and

R_4 is selected from hydrogen and alkyl of one to four carbon atoms.

53. The process according to claim 52, wherein R_1, R_3, and R_4 are independently selected as follows:

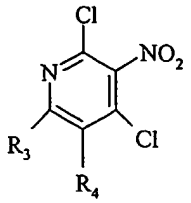
R_1 is selected from 2-hydroxy-2-methylpropyl, 2-methylpropyl, and *n*-butyl;

R_3 is methyl; and

R_4 is selected from hydrogen and methyl.

54. The process of claim 50, further comprising the steps of:

providing a compound of Formula II



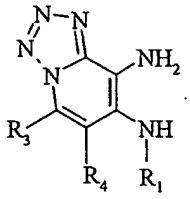
II

wherein R_3 and R_4 are as defined in claim 50; and

reacting the compound of Formula II with a compound of the formula R_1NH_2, wherein R_1 is as defined in claim 50,

to provide a compound of Formula III.

55. The process of claim 50, further comprising the step of reducing the compound of Formula IV to provide a compound of Formula V

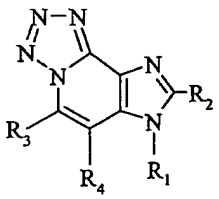


V

wherein R_1, R_3, and R_4 are as defined in claim 50.

56. The process of claim 55, further comprising the step of reacting a compound of Formula V with a carboxylic acid of the formula R_2CO_2H; an equivalent thereof selected from the corresponding acyl halide, $R_2C(O\text{-alkyl})_3$, and $R_2C(O\text{-alkyl})_2(O(O=)C\text{-alkyl})$; or a mixture thereof, wherein each alkyl contains 1 to 8 carbon atoms; and

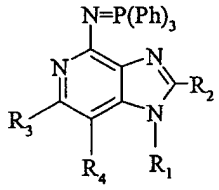
R_2 is selected from hydrogen; alkyl containing one to eight carbon atoms; hydroxyalkyl containing one to six carbon atoms; alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon atoms; benzyl; phenylethyl; phenyl; the benzyl, phenylethyl, or phenyl substituent being optionally substituted on the benzene ring by a moiety selected from methyl, methoxy, and halogen; and morpholinoalkyl wherein the alkyl moiety contains one to four carbon atoms, to provide a compound of the Formula VII



VII

wherein R_2 is as defined above, and R_1, R_3, and R_4 are as defined in claim 55.

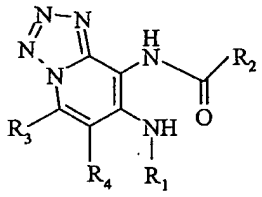
57. The process of claim 56, further comprising the step of reacting the compound of Formula VII with triphenylphosphine to provide an *N*-triphenylphosphinyl intermediate of Formula VIII



VIII

wherein R_1, R_2, R_3, and R_4 are as defined in claim 56.

58. The process of claim 55, further comprising the step of (a) reacting the compound of Formula V with a carboxylic acid of the formula R_2CO_2H or the corresponding acyl halide to form a compound of the Formula VI



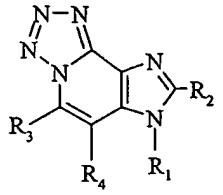
VI

wherein R_1, R_3, and R_4 are as defined in claim 55; and

R_2 is selected from the group consisting of hydrogen; alkyl containing one to eight carbon atoms; hydroxyalkyl containing one to six carbon atoms; alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon atoms; benzyl; phenylethyl; phenyl; the benzyl, phenylethyl, or phenyl substituent being optionally substituted on the benzene ring by a moiety selected from the group

consisting of methyl, methoxy, and halogen; and morpholinoalkyl wherein the alkyl moiety contains one to four carbon atoms.

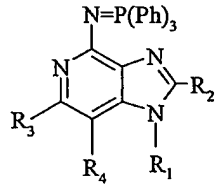
59. The process of claim 58, further comprising the step of (b) subjecting the compound of Formula VI to cyclization conditions, during step (a) or subsequent to the completion of step (a), to provide a compound of the Formula VII



VII

wherein R_1, R_2, R_3, and R_4 are as defined in claim 58.

60. The process of claim 59, further comprising the step of reacting the compound of Formula VII with triphenylphosphine to provide an *N*-triphenylphosphinyl intermediate of Formula VIII



VIII

wherein R_1, R_2, R_3, and R_4 are as defined in claim 59.

61. The process according to claim 8, wherein the reacting of the compound of Formula V with a carboxylic acid of the formula R_2CO_2H; an equivalent thereof selected from the corresponding acyl halide, $R_2C(O\text{-alkyl})_3$, and $R_2C(O\text{-alkyl})_2(O(O{=})C\text{-alkyl})$; or a mixture thereof, wherein R_2 is as defined in claim 8, is done in the presence of cyclization conditions to provide a compound of the Formula VII.

62. The process according to claim 33, wherein the reacting of the compound of Formula Va with a carboxylic acid of the formula $R_{2a}CO_2H$; an equivalent thereof selected from the corresponding acyl halide, $R_{2a}C(O\text{-alkyl})_3$, and $R_{2a}C(O\text{-alkyl})_2(O(O{=})C\text{-alkyl})$;

or a mixture thereof, wherein R_{2a} is as defined in claim 33, is done in the presence of cyclization conditions to provide a compound of the Formula VIIa.

63. The process according to claim 56, wherein the reacting of the compound of Formula V with a carboxylic acid of the formula R_2CO_2H; an equivalent thereof selected from the corresponding acyl halide, $R_2C(O\text{-alkyl})_3$, and $R_2C(O\text{-alkyl})_2(O(O=)C\text{-alkyl})$; or a mixture thereof, wherein R_2 is as defined in claim 56, is done in the presence of cyclization conditions to provide a compound of the Formula VII.

64. The process according to claim 10, wherein the alkali metal azide is sodium azide.

65. The process according to claim 19, wherein the alkali metal azide is sodium azide.

66. The process according to claim 35, wherein the alkali metal azide is sodium azide.

67. The process according to claim 44, wherein the alkali metal azide is sodium azide.

68. The process according to claim 50, wherein the alkali metal azide is sodium azide.

69. The process according to claim 9, wherein the compound of Formula IV is reduced with a heterogeneous hydrogenation catalyst.

70. The process according to claim 18, wherein the compound of Formula IV is reduced with a heterogeneous hydrogenation catalyst.

71. The process according to claim 34, wherein the compound of Formula IVa is reduced with a heterogeneous hydrogenation catalyst.

72. The process according to claim 43, wherein the compound of Formula IVa is reduced with a heterogeneous hydrogenation catalyst.

73. The process according to claim 55, wherein the compound of Formula IV is reduced with a heterogeneous hydrogenation catalyst.

74. The process according to claim 17, wherein in the compound of Formula V is reacted with the corresponding acyl halide to form the compound of Formula VI, and the compound of Formula VI is subjected to cyclization conditions which include an elevated temperature and the presence of pyridine hydrochloride.

75. The process according to claim 74, wherein the acyl halide is ethoxyacetyl chloride.

76. The process according to claim 42, wherein in the compound of Formula Va is reacted with the corresponding acyl halide to form the compound of Formula VIa, and the compound of Formula VIa is subjected to cyclization conditions which include an elevated temperature and the presence of pyridine hydrochloride.

77. The process according to claim 76, wherein the acyl halide is ethoxyacetyl chloride.

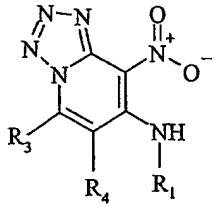
78. The process according to claim 59, wherein in the compound of Formula V is reacted with the corresponding acyl halide to form the compound of Formula VI, and the compound of Formula VI is subjected to cyclization conditions which include an elevated temperature and the presence of pyridine hydrochloride.

79. The process according to claim 78, wherein the acyl halide is ethoxyacetyl chloride.

80. The process according to claim 1 wherein the compound of Formula I is 2-(ethoxymethyl)-1-(2-methylpropyl)-6-methyl-1*H*-imidazo[4,5-*c*]pyridin-4-amine.

81. The process according to claim 25 wherein the compound of Formula Ia is 2-(ethoxymethyl)-1-(2-methylpropyl)-6-methyl-1*H*-imidazo[4,5-*c*]pyridin-4-amine.

82. A compound of the Formula IV



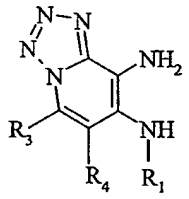
IV

wherein

R_1 is selected from the group consisting of hydrogen; CHR_xR_y wherein R_x is hydrogen and R_y is selected from the group consisting of alkyl or cyclic alkyl containing one to ten carbon atoms, alkenyl containing two to ten carbon atoms, hydroxyalkyl containing one to six carbon atoms, alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon atoms, benzyl, and phenylethyl; and $-C=CR_zR_z$ wherein each R_z is independently alkyl or cyclic alkyl of one to six carbon atoms; and

R_3 and R_4 are independently selected from the group consisting of hydrogen and alkyl of one to five carbon atoms.

83. A compound of the Formula V



V

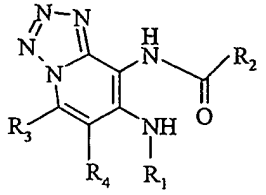
wherein

R_1 is selected from the group consisting of hydrogen; CHR_xR_y wherein R_x is hydrogen and R_y is selected from the group consisting of alkyl or cyclic alkyl containing one to ten carbon atoms, alkenyl containing two to ten carbon atoms, hydroxyalkyl containing one to six carbon atoms, alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon atoms, benzyl, and

phenylethyl; and $-C=CR_zR_z$ wherein each R_z is independently alkyl or cyclic alkyl of one to six carbon atoms; and

R_3 and R_4 are independently selected from the group consisting of hydrogen and alkyl of one to five carbon atoms.

84. A compound of the Formula VI



VI

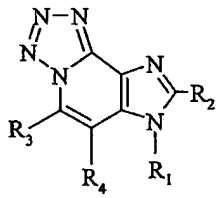
wherein

R_1 is selected from the group consisting of hydrogen; CHR_xR_y wherein R_x is hydrogen and R_y is selected from the group consisting of alkyl or cyclic alkyl containing one to ten carbon atoms, alkenyl containing two to ten carbon atoms, hydroxyalkyl containing one to six carbon atoms, alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon atoms, benzyl, and phenylethyl; and $-C=CR_zR_z$ wherein each R_z is independently alkyl or cyclic alkyl of one to six carbon atoms;

R_2 is selected from the group consisting of hydrogen; alkyl containing one to eight carbon atoms; hydroxyalkyl containing one to six carbon atoms; alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon atoms; benzyl; phenylethyl; phenyl; the benzyl, phenylethyl, or phenyl substituent being optionally substituted on the benzene ring by a moiety selected from the group consisting of methyl, methoxy, and halogen; and morpholinoalkyl wherein the alkyl moiety contains one to four carbon atoms; and

R_3 and R_4 are independently selected from the group consisting of hydrogen and alkyl of one to five carbon atoms.

85. A compound of the Formula VII



VII

wherein

R_1 is selected from the group consisting of hydrogen; CHR_xR_y wherein R_x is hydrogen and R_y is selected from the group consisting of alkyl or cyclic alkyl containing one to ten carbon atoms, alkenyl containing two to ten carbon atoms, hydroxyalkyl containing one to six carbon atoms, alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon atoms, benzyl, and phenylethyl; and $-C=CR_zR_z$ wherein each R_z is independently alkyl or cyclic alkyl of one to six carbon atoms;

R_2 is selected from the group consisting of hydrogen; alkyl containing one to eight carbon atoms; hydroxyalkyl containing one to six carbon atoms; alkoxyalkyl wherein the alkoxy moiety contains one to four carbon atoms and the alkyl moiety contains one to six carbon atoms; benzyl; phenylethyl; phenyl; the benzyl, phenylethyl, or phenyl substituent being optionally substituted on the benzene ring by a moiety selected from the group consisting of methyl, methoxy, and halogen; and morpholinoalkyl wherein the alkyl moiety contains one to four carbon atoms; and

R_3 and R_4 are independently selected from the group consisting of hydrogen and alkyl of one to five carbon atoms with the proviso that when R_1 is hydrogen then at least one of R_2, R_3 or R_4 is other than hydrogen.